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(54) IMPROVEMENTS IN WORKING CYLINDERS

(71) We, KLINGER A.G., of 10 Baarerstrasse, Zug, Switzerland, a body corporate organized according to the laws of Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to working cylinders having a low degree of intrinsic friction. Such cylinders are required not only for control techniques, but also in every case where the operating conditions or the working medium subjecting the cylinder to action produce a high degree of friction between the piston and the inner cylinder wall and also between the piston rod and the bearing bushes. For example, in operational cases in which helium is used as the working medium, since it operates in a deoxidizing fashion, at the contact locations between piston and cylinder wall or between piston rod and bearing bushes, welding of the materials employed may occur; conventional lubricants cannot be employed.

U.S. Patent Specification No. 2,907,304 discloses a working cylinder of the type wherein the displaced elements are mounted in bearing bushes made from permeable material through which gaseous or liquid medium flows from the exterior, such medium being similar to the working medium for subjecting the piston to pressure.

The working cylinder known from the above referred to U.S. Patent is; in the case of the embodiments shown in Figures 2 and 3, displaceable in the two working directions in consequence of the fact that the subjecting to action of pressure medium takes place alternatingly on both piston sides this being relatively costly. In the case of the embodiment shown in Figure 4, the movement in the one or other direction is effected due to the force of a spring. Since a spring loses its force on being decompressed, the retaining force in the end position of the piston is either extremely small or, if a large spring is used, higher pressure of the working medium is necessary.

From German Patent Specification No. 489,034 it is only possible to gather that on providing a throughflow through porous faces the latter can be cooled.

It is an object of the present invention to solve the above problems and disadvantages of the constructions of the prior art and to provide working cylinders with a small degree of intrinsic friction which will operate entirely satisfactory under the most disadvantageous operational conditions.

The invention thus proceeds from the idea of how to select a simple cylinder construction with the smallest possible number of sliding locations, the gaseous or liquid working medium being pressed as a lubricating medium from the exterior through the bearing bushes into the bearing gap, where the bearing clearance required for contactless guiding is maintained due to the aerostatic or hydrostatic forces acting there.

According to the present invention there is provided a working cylinder including: a piston; a piston rod having the piston connected to one end thereof; a jacket surrounding the piston and at least part of the piston rod; a first bush of permeable material associated with the piston; a second bush of permeable material associated with the piston rod; inlet means in the jacket for admitting working medium to act on one face of the piston; inlet means in the jacket to said first and second bushes for admitting a lubricating medium; which lubricating medium is identical to the working medium, the inlet pressure of said lubricating medium being equal to that of the working medium, there being a pressure drop across the first bush so that when the piston is moved under pressure, it is able to do so because of the difference in pressure between the working medium on one face and the lubricating medium at a reduced pressure on the other face.

In this manner, there is obtained a working cylinder having bushes of permeable material, which is especially simple because, for displacement of the piston, subjecting to pressure is necessary only from one side. For displacement of the piston in the opposite direction and for subsequent retaining in the end position, the lubricating medium entering into the cylinder chamber is em-

ployed and this lubricating medium performs this function without a separate control device.

The present invention will now be described in greater detail by way of example with reference to the accompanying drawing wherein the sole figure shows a schematic axial section through a preferred form of working cylinder which, for operating shut-off means, is to be subjected to the action of helium as the working medium at high temperatures.

Referring to the drawing, the working cylinder includes a piston 1 which is connected with a piston rod 2 at one end thereof and mounted in a permeable cylinder bush 3 comprising two axial sections 3^{1}, 3^{11}. The piston rod 2 is mounted in a permeable bearing bush sub-divided into three axial sections 4^{1}, 4^{11}, 4^{111}. These bushes 3 and 4 are made from porous sintered carbon which even in the event of elimination of the lubricating medium which is identical with the working medium, afford good emergency running properties. The cylinder bush 3 is mounted in an external cylinder 5, whilst the bearing bush 4 is mounted in a projection 6^{1} of one of the cylinder covers 6. Another cylinder cover 7 does not have a piston rod extending through it and contains the supply arrangement for the working medium. The porous carbon bushes 3 and 4 are sealed off at the end faces relative to the surrounding material.

The feed of the lubricating medium to the annular chambers 9, 10, 11^{1}, 11^{11}, 11^{111} in the external cylinder 5 and in the cylinder cover projection 6, which surround the external jacket of the bushes is effected radially from the exterior, so that subjecting to pressure takes place uniformly over the entire jacket. If it should be possible under special operating conditions for the pressure within the bushes to be considerably smaller than in the annular chambers, there may be provided short axial spacing beads which support the bushes against rupture and which however must have axial passages in the form of radial interruptions, in order that the lubricating medium is able to flow practically about the entire external jacket of the bushes. At each end of each axial section 4^{1}, 4^{11}, 4^{111} of the bearing bushes 4, there are provided ducts 12 for discharging the lubricant. Thus, each section can be dimensioned in an optimum fashion and it is therefore possible to achieve the necessary bearing capacity with the minimum quantity of lubricant.

As already stated, the cylinder piston 1 is subjected to the action of the pressure medium from the cylinder cover 7. On the other side of the piston there is obtained in the cylinder the pressure of the atmosphere surrounding the cylinder, because this cylinder chamber is connected via bores 13 in the cylinder cover 6 with the surrounding atmosphere. If this pressure should be inadequate for retaining the piston 1 in the inoperative position, instead of the bores 13 pressure retaining valves may be built into the cylinder cover 6, and these maintain a pre-set pressure of the lubricating medium which has passed through the permeable cylinder bushes into the cylinder chamber.

In order to save lubricating medium, i.e. helium, the cylinder bush 3 is sub-divided into the two sections 3^{1} and 3^{11}, i.e. into a first section 3^{11} in which the piston 1 is mounted in the inoperative position and a second section 3^{1} which becomes effective only on the piston being subjected to pressure and displaced into the other dead-centre position and which during the movement of the piston guides the latter contactless towards the bushes. In operation, in the case of the present example, the following working characteristics results:

The entire working cylinder is mounted in an atmosphere of helium at a pressure of 43 bars. As the lubricating medium for the bearing bush 4, cold helium is forced through an inlet 14 under a pressure of 45 bars, and the helium flows out of the ducts 12 at the end of the bearing bush sections 11^{1}, 11^{11} and 11^{111} under a pressure of 43 bars into the surrounding atmosphere and simultaneously acts directly as cooling medium. The lubricating medium for the section 3^{11} of the cylinder bush, through which there is a continuous flow and in which the piston 1 is in the inoperative position, passes via baffle plates 15 under an inlet pressure of 45 bars into an inlet 16 of the outer cylinder 5 and from there via the annular chamber 10 and through the permeable section 3^{11} into the bearing gap in the piston 1. The lubricating medium enters firstly directly at its end and secondly via an annular groove 1^{1} and radial bores 1^{11}. The lubricating medium flows out into the cylinder chamber connected with the external atmosphere of 43 bars through the bores 13. If the length of the piston is large enough, it is generally necessary to provide a plurality of such annular grooves 1^{1} and radial bores 1^{11} for discharging the lubricating medium, so as to be able to achieve the desired bearing force with the smallest consumption of lubricant. The remaining cylinder bush section 3^{1} is, in the inoperative position of the piston, not subjected to pressure. The introduction of helium to this section is as in the case of the other bush section 3^{11}. As soon as the piston is subjected to the helium at a pressure of 45 bars as the working medium through the supply arrangement in the cylinder cover 7, the second cylinder bush section 3^{1} is also put under a helium pressure of 45 bars, so that the piston 1 is able

to travel over the entire cylinder length, maintaining the bearing gap. Thus, lubricating medium is fed to the larger portion of the cylinder bush length only when it is really required. At that portion of the cylinder, which on movement of the piston passes into position on that side of the piston subjected to the helium working medium at a pressure of 45 bars, there is no flow through the cylinder bush portion present there, because at both jacket faces of this cylinder bush portion the same pressure of 45 bars prevails so that no flow can occur. This results in a saving of lubricating medium. In the present case, the necessary carrier effect at the piston is afforded due to the 2 bar pressure difference between the external and inner jacket of the cylinder bush. If, for achieving the correct carrier force with unchanged inlet pressures some other pressure difference should be necessary, it will be necessary to achieve this, either by varying the pressure of the surrounding atmosphere or by providing a pressure-holding valve.

The above described working cylinder guarantees therefore also under extreme operating conditions the necessary sliding properties which are considerably better than in the case of a piston having mechanical guiding of piston rod and piston. Thereby, the quantity of gaseous or liquid medium necessary for lubrication is, due to the abovedescribed measures, reduced as far as possible, without a large technical outlay making the construction liable to breakdown.

Thus, the above construction provides a simple piston, wherein due to the carrying forces in the bearing gap, when the piston is subjected to pressure there is only a small degree of friction. Simultaneously, in the event of employment under high external pressure cooling is also effected due to the lubricating medium flowing through the bushes from the exterior, which said lubricating medium additionally prior to introduction into the cylinder or into the bearing is able to flow also through jacket-like envelopes about the cylinder or the bearing from the exterior to afford a cooling effect. As permeable material, sintered carbon or sintered metal can be advantageously employed.

In the case of such working cylinders, also a special problem arises, inasmuch as the contact locations between cylinder bushes and piston must be subjected to the pressure of lubricant over the entire piston path and therefore a large quantity of lubricating medium must be circulated. The above described working cylinder substantially reduces the necessary amount of lubricant, inasmuch as in the zone of the cylinder only the particular contact locations with the piston are subjected to the pressure of the lubricating medium. This is achieved advantageously in that the lubricating medium and the working medium have the same inlet pressure. In those cylinder sections, therefore, where the working medium becomes effective depending on subjecting to pressures the same inlet pressure is obtained at the inner wall and at the outer wall of the cylinder bush, so that there no medium flows through the bush wall and consequently does not require to be circulated and cooled.

However, it is also possible alone or in combination with the abovementioned design for the permeable cylinder bush and/or the permeable bearing bush to have axial sections through which lubricating medium is able to flow separate from each other. If, therefore, a piston remains for long in an inoperative position, the result may be achieved therewith that only the associated axial section of the permeable cylinder bush has a flow through it and the remaining section of the bush is not subjected to pressure. Also thereby a saving in respect of lubricating medium requiring to be circulated is achieved. Also at the bearing bush there is achieved a saving in respect of lubricating medium due to sub-division of the bush into a plurality of axial, separate sections, because each of these sections has a separate flow through it and can be selected in the correct length affording maximum carrier force.

An especially advantageous construction is achieved if, in the case of an embodiment wherein the lubricating medium and the working medium have the same inlet pressure, the piston is subjected to the pressure medium unilaterally, whereas the cylinder bush section located externally of the inoperative piston which is not subjected to action has the lubricating medium flowing through it only when the piston is subjected to the action of the pressure medium. On the cylinder side where the piston is subjected to pressure, automatically and independently of the piston position those cylinder sections do not have lubricating medium flowing through them which come into contact with this working medium, since the lubricating medium and the working medium have the same inlet pressure and no flow through the bush takes place; since the piston, in the condition in which it is not subjected to pressure is always in the inoperative position due to a static pressure acting on the other piston side, either of a medium or of a spring, the axial cylinder section which in the inoperative position is not in contact with the piston can be eliminated from the throughflow of lubricant and only on movement of the piston have a flow through it due to the subjecting to pressure by the lubricating medium.

Furthermore, it is advantageous for the purpose of achieving a saving of the lubricating medium if both axial ends of the piston jacket carried by the lubricating medium are connected directly or by ducts with the same piston side, since then at both ends of the piston jacket the same outlet pressure is obtained for the lubricating medium out of the bearing gap and thereby no higher pressure of the lubricating medium must be selected as necessary. This is found to be especially advantageous if the two ends of the piston jacket are connected with the piston side which is not subjected to pressure, whereby due to adjustment of a pressure obtaining there the radial bearing ability of the piston and the consumption of lubricating medium are optimized.

WHAT WE CLAIM IS:—

1. A working cylinder including: a piston; a piston rod having the piston connected to one end thereof; a jacket surrounding the piston and at least part of the piston rod; a first bush of permeable material associated with the piston; a second bush of permeable material associated with the piston rod; inlet means in the jacket for admitting working medium to act on one face of the piston; inlet means in the jacket to said first and second bushes for admitting a lubricating medium, which lubricating medium is identical to the working medium, the inlet pressure of said lubricating medium being equal to that of the working medium, there being a pressure drop across the first bush so that when the piston is moved under pressure, it is able to do so because of the difference in pressure between the working medium on one face and the lubricating medium at a reduced pressure on the other face.

2. A working cylinder according to claim 1, wherein the piston is provided with at least one annular groove and a plurality of radial bores for discharging the lubricating medium.

3. A working cylinder according to claim 1 or 2 wherein the first permeable bush comprises two separate axial sections which are separate from each other and have separate supplies of lubricating medium.

4. A working cylinder according to any one of the preceding claims, wherein the second permeable bush comprises three separate axial sections which are separated from each other and have separate supplies of lubricating medium.

5. A working cylinder according to claim 3, wherein that section of the first bush which is located behind the piston in the inoperative location, has lubricating medium flowing through it only when the piston is subjected to the pressure from the working medium.

6. A working cylinder according to any one of the preceding claims, wherein said first and second bushes are made of porous sintered carbon.

7. A working cylinder according to any one of the preceding claims, wherein said working and lubricating mediums are helium.

8. A working cylinder constructed and arranged to operate substantially as herein described with reference to and as illustrated in the accompanying drawing.

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1 SHEET

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.